

QUARTERLY REPORT

1. **Contract Number:** DAMD17-91-C-1081
2. **Report Date:** 13 June 1994
3. **Reporting Period:** 16 February 1994 to 15 May 1994
4. **Principal Investigator:** Dr. Victor Klymenko is acting Project Director
Dr. Thomas Harding is Project Director as of 7 March 1994
5. **Telephone:** (205) 598-6389, FAX (205) 598-9256
6. **Institution:** UES, Inc.
4401 Dayton-Xenia Road
Dayton, Ohio 45432
7. **Project Title:** Development of Data Packages on the Human Visual Response with Electro-optical Displays
8. **Current staff, with percent effort of each on project:**

NAME	TITLE	HOURS*	% OF EFFORT
Dr. Thomas Harding*	Project Director	387	78%
Dr. Victor Klymenko	Research Psychologist	476	96%
Mr. Howard H. Beasley	Electronics Technician	442	89%
Mr. John S. Martin	Electro-optics Technician	463	93%

496 hours were available this reporting period not including holidays. The above hours are the actual hours worked (sick leave and annual leave have been subtracted).

* Dr. Thomas Harding began work on 7 March 1994 taking over duties previously performed by Dr. Robert W. Verona who was placed on permanent long term disability as of 4 November 1993.

9. **Contract expenditures to date:**

Personnel	\$661,021.57	Equipment & Supplies	\$ 6,336.01
Travel	11,285.02	Other	6,195.14
TOTAL*			\$684,837.74

* Does not include facilities capital and G&A expense.

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10. Comments on administrative and logistics matters:

Dr. Thomas Harding began work on 7 March 1994 as the projects Principal Investigator, taking over the duties previously performed by Dr. Robert W. Verona who was placed on permanent long term disability as of 4 November 1993 and Dr. Victor Klymenko who was acting Director.

11. Scientific Progress:

Physical Measurements:

Efforts were devoted to initiating physical measurements and completing the documentation and review chain requirements of past psychophysical measurements. In addition, three papers on previous work were presented at various conventions.

The "Dynamic Sine Wave Response Measurement of CRT Displays Using Sinusoidal Counterphase Modulation" paper written by Robert W. Verona, Howard H. Beasley, John S. Martin, Victor Klymenko and Clarence E. Rash was delivered at the 1994 SPIE convention. The paper was completed as a UES project deliverable and is being converted to a USAARL reprint report.

Static and dynamic modulation transfer functions (MTF) were measured on several miniature cathode ray tubes (CRTs) with different phosphors. The MTFs agreed well with expectations. A general falloff in contrast at the higher spatiotemporal frequencies was observed. While collecting the data, harmonic distortions in the measured luminance profiles were evident. The profiles showed a marked tendency to exhibit nonlinearities probably associated with compressed voltage-luminance response curves, although applied dc voltages showed quasi-linear luminance response functions. It appears that although the MTF has been historically used for assessing CRTs it may not always provide the best human factors assessment of resolution.

Preparations have begun for a physical evaluation of the CVCHMD (Combat Vehicle Crewman Helmet Mounted Display). The CVCHMD uses a miniature flat panel display with optics that form an exit pupil at the soldiers eye. To garner experience with systems that form exit pupils, development of physical measures to be used in assessing the IHADSS has been initiated. These measures included: (A) The size and location of the exit pupil: Using a short distance telescope with an extended reticle we measured the diameter of the circular exit pupil at various distances from the HMD and bracketed the position which provided the smallest exit pupil diameter. Repeated measurements were made of the diameter at locations close to the exit pupil and by using statistical methods to locate the exit pupil. (B) The distance from the exit

pupil to the last lens in the HMD: Using a short distance telescope mounted to a parallel optical bench, the distance was measured from the last lens to the exit pupil and the measure for statistical reliability was repeated. (C) Eye relief with the combiner lens in place: Using the same technique as in B the eye relief was measured. (D) Luminance uniformity: Pilot luminance uniformity was measured by focusing a photometer on the exit pupil such that the exit pupil filled the aperture. The CRT displayed a uniform luminance field. The HMD were rotated about a central point located at the exit pupil and measured the luminance. An increased falloff in luminance with increased eccentricity was observed. (E) Combiner lens spectral transmissivity and spectral reflectance: Measurement of the spectrum of a broad band light source with and without the combiner lens in place was performed. By dividing the spectrums, the spectral transmissivity curve was recorded. Taking the reciprocal of the transmissivity curve, produced the reflectance curve. (F) Spectral output of the HMD: Measurements of the spectral output of several phosphors for phosphor identification and measurement of the spectral output of the HMD was taken. The combiner reflectance spectrum agreed well with the output spectrum. (G) Field-of-view: No measurements were taken on the field-of-view (FOV) in the IHADSS however, the FOV will be measured in a fashion similar to previous uniformity measures. Rather than focusing the photometer at the exit pupil, focus will be to the infinity providing an image of the actual display. Rotating the HMD at the exit pupil, will result in photometrically measuring the eccentric portions of the display and thus measure field of view. (H) Static and dynamic MTFs: Please see above.

In preparation of evaluating flat panel displays, especially liquid crystal displays, the literature on LCD technology and human factors assessment methodology were reviewed. Because LCD arrays are composed of discrete pixels/subpixels, their spatial resolution should be generally predictable. Several different types of matrices were microscopically examined and each matrix configuration taken into account during analytically examination of spatial resolution. Although matrix geometry does not have a profound effect on spatial resolution, it does have a significant effect. From the literature, information was gathered on how to predict spatial resolution given the type of matrix. A white paper on figures-of-merit for liquid crystal displays was also prepared. When the CVCHMD arrives, an understanding on how to examine liquid crystal displays and systems that form exit pupils at the soldier's eye should be complete.

Psychophysical Measurements:

Four psychophysical reports were forwarded to Dr. Wiley, COR, and Dr. Kimball, AMLO. The reports describe visual performance experiments testing the effect of different factors used in helmet mounted displays. The first three reports are in the USAARL review chain and are being converted to USAARL lab reports. The fourth is a USAARL reprint report. The USAARL reports, titles and authors, are: (1) "Factors Affecting the Perception of Luning in Monocular Regions of Partial Binocular Overlap Displays," by Victor Klymenko, Robert W. Verona, John S. Martin, Howard H. Beasley and William E. McLean; (2) "Factors Affecting

the Visual Fragmentation of the Field-of-View in Partial Binocular Overlap Displays," by Victor Klymenko, Robert W. Verona, Howard H. Beasley, John S. Martin and William E. McLean; (3) "The Effect of Binocular Overlap Mode on Contrast Thresholds Across The Field-of-View as a Function of Spatial and Temporal Frequency." by Victor Klymenko, Robert W. Verona, John S. Martin, Howard H. Beasley and William E. McLean; and (4) "Convergent and Divergent Viewing Affect Luning, Visual Thresholds and Field-of-View Fragmentation in Partial Binocular Overlap Helmet Mounted Displays" by Victor Klymenko, Robert W. Verona, Howard H. Beasley and John S. Martin.

Two presentations were given at scientific meetings based on the above work: (1) "Convergent and Divergent Viewing Affect Luning, Visual Thresholds and Field-of-View Fragmentation in Partial Binocular Overlap Helmet Mounted Displays" by Victor Klymenko, Robert W. Verona, Howard H. Beasley and John S. Martin. given at the 1994 SPIE Convention, and (2) "Naso-Temporal Retinal Asymmetry in Dichoptic Competition and Diplopia Suppression" by Victor Klymenko, Robert W. Verona, John S. Martin, Howard H. Beasley and William E. McLean, given at the 1994 ARVO convention.

It is important to know how accurate the calibration of the two images of a binocular device needs to be because of cost and other factors. Due to optical and electronic factors (such as optical axis orientation deviation due to vibration and CRT image drift), perfect alignment of the images in a binocular HMD is not practical. It is important to understand what the human tolerance requirements are. To do this a new (abbreviated) protocol entitled "Visual Performance Effects of Horizontal and Vertical Binocular Misalignment" by Victor Klymenko was submitted to Dr. Wiley. The two purposes of this protocol are: (1) to test a new psychophysical performance measure to determine if it can be used to test the effects of different system design factors on the binocular tolerance requirements of HMDs, and (2), to test the effect on visual performance of various degrees of vertical and horizontal misalignment in a full overlapped binocular vision system. If the technique is efficacious, it may be useful in the future to measure the tolerance effects of such factors as partial overlapping displays, field-of-view size, etc. Subjects will be run with this protocol in our binocular vision laboratory this quarter.

Milestones:

Efforts will focus on the new psychophysical protocol, testing the CVCHMD, and finalizing generalized figures-of-merit for flat panel displays during next quarter.